TOTAL AND SOLUBLE DIETARY FIBER INTAKE OF FEMALE RUNNERS

by

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B. S., Kansas State University, 1982

A MASTER'S THESIS

submitted in partial fulfillment of

the requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1988

Approved by:

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INTRODUCTION

Today an increasing number of Americans are concerned about their fitness and health. They are eating more healthful foods and exercising regularly. Many Americans have decreased their intake of saturated fats and cholesterol while increasing their intake of polyunsaturated fats (1). In addition to decreasing their fat consumption, they are eating more high carbohydrate foods such as fruits, vegetables, and bread and cereal products which are high in dietary fiber.

Several investigators have found that a high fiber diet can lower total serum and low-density lipoprotein (LDL)-cholesterol (2-4), while others (5) have found no affect. Some investigators reported that certain types of fiber can increase high-density lipoprotein (HDL)-cholesterol levels (6-8). HDL-cholesterol accounts for only 20 to 25 percent of total serum cholesterol, but the higher the level of HDL, the lower the risk of atherosclerosis (9). In addition to diet, exercise is a very important part of total wellness. Moderate aerobic exercise such as walking, jogging, or running has been associated with a decrease in total serum cholesterol and an increase in HDL-cholesterol levels (9-12).

The purpose of this study was to determine whether there were differences in total and soluble fiber intake

among young women who participated in regular running programs (20-30 miles/week or 40-50 miles/week) and sedentary controls. In addition, the relationship of fiber intake to serum lipids was studied.

REVIEW OF LITERATURE

FIBER

Definitions

For many years, crude fiber measurements were used to estimate the fiber content of food products. Crude fiber is the portion of the plant that is resistant to digestion by strong acid or alkali treatment in the laboratory (13). However, crude fiber determination grossly underestimates the dietary fiber content of most foods. Dietary fiber has been unofficially defined as complex macromolecular plant substances that are resistant to mammalian digestive enzymes. Another definition states that dietary fiber is the sum of lignin and the plant polysaccharides that are not digested by the endogenous secretions of the human digestive tract (15).

Total dietary fiber includes both soluble and insoluble fibers (16). Water-soluble fibers can be extracted with boiling water and include pectins, gums, and storage polysaccharides. Insoluble fibers are cellulose, lignin, and insoluble polysaccharides such as insoluble noncellulosic polysaccharides or hemicelluloses. Cellulose is a water insoluble, beta 1-4 linked glucose polymer. Lignin is a water-insoluble, phenylpropane polymer.

Chemistry

Water-Insoluble Fibers

Cellulose is the most abundant molecule in nature (17) and is considered to be relatively insoluble (18). Cellulose is a linear polymer of glucose linked by beta 1-4 bonds (17-20). The structure obtained with this type of linkage strongly favors the formation of hydrogen bonding between sugar units in the chain and between adjacent chains (17). Flat, ribbon-like molecules are packed into partly crystalline chains or microfibrils, 4000-6000 mm long and approximately 4 nm in diameter (17-19). The cellulose fibers in the plant cell wall are formed when the microfibrils are woven together (17).

Hemicelluloses generally have 50 to 200 glucose units and at least 250 chemically different hemicelluloses are known (17). Hemicelluloses have a wide range of solubilities, with a greater solubility related to a high degree of branching (18). They are heterogenous groups containing branched polymers of pentose and hexose sugars (18,19). Hemicelluloses have been classified by their neutral or acidic properties, the type of monosaccharide they contain, or the number of carbons in the predominant sugar (17).

Lignins are inert, insoluble, and resistant to digestion (18). They have a highly complex, three-dimensional structure built up by polymers of phenylpropane or aromatic

alcohols (17-20). They are formed by a complex enzymatic dehydrogenative polymerization process of cinnamyl alcohols, coniferyl-, sinapyl-, and p-coumaryl alcohol (17-20). Lignins give rigidity to cell walls and act as bonding agents between cells (17). There are three classifications for lignins: softwood (gymnosperm), hardwood (dicotyledonous angiosperm), and grass (monocotyledonous angiosperm) lignins (20).

Water-Soluble Fibers

Pectins are considered to be highly soluble and are found universally in the primary cell walls and as intercellular cement in land plants (18,19). They are a complex group of colloidal polysaccharides in which D-galacturonic acid is a primary constituent (17-19). Pectins are partially esterified rhamnogalacuronans with an alpha 1-4 linked D-galacturonan chain interspersed with L-rhamnopyranosyl residues with side chains which include D-galacturonic and glucuronic acids (19,20).

Gums are water-soluble viscous polysaccharides made up primarily of glucose, galactose, mannose, arabinose, and rhamnose (10,000-30,000 units) and their uronic acids which may be acetylated or methoxylated (19). The food industry commonly uses gums such as gum arabic, alginates, tragacanth, guar gum, carboxymethylcellulose, carob gum, karaya gum, carrageenan, and locust bean gum for their thickening

and/or gelling effects (19,20). These gums are exudates from stems or seeds of tropical and semi-tropical trees and shrubs (19).

Mucilages are soluble polysaccharides from seeds and seaweeds used in the food industry as thickening and stabilizing agents (19,20). The mucilages from seeds of ispaghula husks are bulk laxatives made up of highly branched arabionoxylans which are widely used to treat large bowel disorders such as diverticular disease. Seaweed contains alginic acid, a polymer of 1-4 linked beta-D-mannuronic acid or of 1-4 linked alpha-L-guluronic acid or a combination of both.

Physical Properties

Bacterial Degradation

According to Schneeman (18), bacterial degradation is relevant to only the polysaccharide fraction of fiber. Dietary fiber can be fermented to varying degrees of degradation within the large bowel. Pectins, mucilages, and gums are completely broken down while cellulose is only partially degraded. The extent of bacterial degradation can influence physiological responses such as the production of short-chain fatty acids, flatulence, and acidity.

Water-holding Capacity

Water-holding capacity is significantly enhanced in polysaccharides by the presence of sugar residues with free polar groups (18). Pectins and mucilages have the greatest water-holding capacity. The formation of a gel matrix is the result of hydration of the fibers. The water-holding capacity of fiber can affect nutrient absorption, fecal weight, and rate of transit in stomach and small intestine (18). The relationship between water-holding capacity of fiber in the colon and fecal bulking is very complex (19).

Cation-exchange

The cation exchange properties of fibers seem to be related to the number of free carboxyl groups on the sugar residues and the uronic acid content of polysaccharides (18). The cation exchange capacity of dietary fiber varies with the plant species and is a property of the plant cell wall (19). The cation exchange capacity may be lost after bacterial fermentation since it does not alter electrolyte metabolism (19). High fiber diets have been associated with reduced mineral availability and electrolyte absorption, due to the binding of minerals and electrolytes on fiber sources, and results in increased fecal excretion of minerals and electrolytes (18).

Adsorption properties

Dietary fiber adsorbs organic molecules such as bile acids, cholesterol, many drugs, and toxic compounds

(18,19). Lignin is a major bile acid adsorbent; others include pectin, and other acidic polysaccharides (18). Processing, particle size, and bacterial fermentation affect adsorption properties of fiber (19). Certain soluble, noncellulose polysaccharides such as pectin and guar gum increase fecal bile acid excretion which has been correlated with lowering plasma cholesterol levels (18).

Methods of Analysis

There are multiple analytical methods for determining the fiber content of foods. The type of method depends on the type of fiber being investigated. Extraction methods are used to determine the amount of crude fiber, cellulose, hemi-cellulose, lignin, and pectic substances in food. Enzymatic procedures can be used to determine both soluble and insoluble fiber content in food.

Extraction Methods

Crude Fiber. Crude fiber is the residue left after a food has been treated with hot acid or alkali. The oldest method for fiber analysis is the "crude fiber" method which destroys all the soluble fiber fraction and a variable amount of the insoluble dietary fiber (17). The crude fiber method may be used to test grains, meals, flour, animal feeds, and other materials containing fiber (21).

Southgate (21) stated that the procedure for determining crude fiber involves adding the reagents (sulfuric acid, sodium hydroxide, asbestos, alcohol, antifoaming agent, and a boiling stone) to the fat-free material which is boiled, filtered, ashed and dried. The results indicate only approximate amounts of the cellulose and lignin in food. Schneeman (18) pointed out two disadvantages to the crude fiber method: 1) It does not measure any specific carbohydrate or group of carbohydrates; and 2) it does not accurately estimate the dietary fiber content.

Neutral Detergent Fiber (NDF). Neutral detergent fiber contains all the cell-wall except the water-soluble components (21). It is a good estimate of the insoluble structural polysaccharides and lignin content of food (18). The Van Soest neutral detergent fiber (NDF) method has the advantage of being a relatively rapid procedure and the most convenient assay for water-insoluble dietary fibers (17,18). The NDF method assumes that dietary fiber can be qualitatively and specifically separated from the protein, starch, and lipid components of food by boiling with sodium lauryl sulfate at neutral pH. The nonsoluble fibers are separated by filtration. The disadvantage of this method is that water-soluble fibers are lost during this process. The NDF procedure greatly underestimates the fiber content of fruit and nearly all leafy and root vegetables. Those

analytical limitations must be taken into consideration when interpreting values in food fiber tables.

Acid Detergent Fiber. Acid detergent fiber includes all the cellulose and lignin in the food, i.e. the residue obtained from the method which can be used for measurement (17,21). The method involves extraction with hot N-sulfuric acid containing cetyl trimethyl ammonium bromide (CTAB) in which the ground sample is boiled under reflux, filtered with hot water, washed with acetone, and dried for 8 hours at 100°C (21). The acid detergent fiber method is a good estimate of cellulose and lignin content of food (17,21).

Other Methods. Other methods involve the extraction of hemicellulose with a strong or weak alkali under nitrogen conditions. Cellulose residue is insoluble in 17.5% sodium hydroxide. Lignin can be extracted with 72% sulfuric acid (21).

Analysis of Individual Components

The Southgate procedure is the best known of this type of analysis which involves removing the individual fractions through a series of extraction steps (21). This procedure involves the preparation of the sample; extraction of free sugars and preparation of the residue insoluble in 85% methanol; enzymatic hydrolysis of starch; extraction of water-soluble material; hydrolysis with dilute acid; and extraction of cellulose.

The individual fiber components must be separated first and then hydrolyzed to monomeric components. Starch is removed by enzymatic hydrolysis and the residue is separated into cellulose, noncellulosic polysaccharides, and lignin by a series of extraction steps. After acid hydrolysis of each fraction, the sugar components are determined by gas-liquid or liquid chromatography. This procedure is difficult and time-consuming, but is vitally important in understanding the variability in physiological response included by different sources of fiber (21).

Chen and Anderson (16) used a modified version of Southgate's procedure to examine the fiber content of selected cereals and vegetables. Their method involved sample preparation, methanol and alpha-amylase hydrolysis, extraction of water-soluble fraction, extraction of water-insoluble polysaccharide, extraction of cellulose fraction, determination of lignin fraction, sugar analysis in acid hydrolysates, and gas-liquid chromatography. The alpha-amylase hydrolysis separated starch. The boiling water extraction step separated the water-soluble and insoluble components. Gas-liquid chromatography measured the hydrolyzed sugars.

Enzymatic Procedures

Berlin Method. This method may be used to determine total, soluble, and insoluble dietary fiber in a wide range

of food. Becker et al. (22) stated that all dietary fiber substances or physiological activity should be determined by this method. They outlined the following procedure for this method. After grinding and defatting; the sample is autoclaved, extracted, and centrifuged. An enzymatic hydrolysis is used to separate the centrifugate and the extract. The soluble dietary fiber is separated after the enzymatic hydrolysis of the glucose polymers, proteins, and other macro-molecular components. Soluble dietary fibers are the substances in the retained fraction that are determined gravimetrically.

Rapid Enzymatic Procedure. Schneeman (18) reported that the rapid enzymatic procedure provides a single value for the soluble and insoluble fiber content of the food and does not comprehensively determine individual fiber components. This procedure involves enzymatic removal of protein and starch from fat-extracted food. The residue is corrected for ash and protein content, and fiber is determined gravimetrically.

Enzymatic Neutral Detergent Fiber. According to Lanza and Butrum (17), this procedure is the most widely used dietary fiber analysis method in the United States today. Amylase treatment occurs during detergent extraction. This method removes starch interference and provides a good estimate of total dietary fiber in cereal products, since

wheat and milled rye products lack a significant amount of water-soluble components.

Qualitative Tests. Qualitative tests are used to determine the type of gum present in foods (21). These tests are performed on the alcohol-precipitated material from a hot water extract. The addition of iodine potassium iodide in zinc chloride to the precipitate will identify the presence of tragacanth, starch, and quince gums. Agar and carrageenan gums are identified by testing with alcoholic iodine. Ruthenium red is used to determine whether karaya gum is present in foods. Warm, concentrated sulfuric acid will identify the presence of carob bean and acacia gums.

Fiber Content of Foods

Chen and Anderson (16) measured both soluble and insoluble plant fiber contents of selected cereals and vegetables. A modified version of Southgate's method was used to separate plant fiber into soluble and insoluble fractions. The fractions were hydrolyzed with dilute sulfuric acid and trifluoracetic acid. The fiber content of selected cereals, beans, and vegetables were examined. Corn, oat, cooked pinto beans, cooked white beans, and cooked kidney beans were found to be rich in soluble fiber. Wheat bran, green pepper, cucumber, asparagus, and kale were rich in insoluble fiber.

Johnson and Marlett (23) determined the mean NDF content of unrefined grain products, legumes, fruits, vegetables, and refined grain products. The mean NDF content of unrefined grain products was generally high, ranging from 1.0 g/serving for cooked barley to 11.2 g/serving for wheat bran. The average NDF content of legumes was 3.1 ± 0.9 g/serving. The mean NDF contents of fruits (1.2 ± 0.9 g/serving) and vegetables (0.9 ± 0.4 g/serving) were low. Refined grain products had the lowest mean NDF value (0.4 ± 0.2 g/serving).

Patrow and Marlett (24) determined the dietary fiber contents of wheat and mixed grain commercial breads. The neutral detergent fiber method indicated white bread contained 0.5 gm NDF/slice while wheat bread had a NDF content of 1.5 gm/slice.

Zyren et al. (25) determined insoluble neutral detergent fiber and soluble pectin contents of fruits and vegetables. The effect of processing on the fiber contents of several products was determined. Raw, home cooked, and commercially processed fruits and vegetables were analyzed. Neutral detergent fiber and Southgate's total dietary fiber procedures were implemented. Juices contained higher levels of soluble pectin than insoluble fibers. The processing methods had little effect on the fiber content of fruits and vegetables.

Ross et al. (26) analyzed the neutral detergent fiber, cellulose, hemicellulose, lignin, and pectin content of selected fresh and processed fruits and vegetables. Fresh apples and fresh cooked green beans were highest in dietary fiber, neutral detergent fiber, hemicellulose, and cellulose. Fresh strawberries and fresh cooked potatoes were highest in lignin. Fresh oranges and fresh cooked carrots contained the highest amount of pectin. The fiber content of fruits and vegetables varied according to type or variety of fruit and vegetables, store of purchase, or processing method. Further research is needed to determine the fiber content of other foods.

EFFECT OF DIETARY FIBER ON BLOOD LIPIDS

Dietary intake of certain fibers has been associated with selective alterations in serum lipoproteins which may reduce the risk of coronary heart disease. The type and amount of dietary fiber seems to be a significant factor in determining whether HDL-cholesterol is increased and LDL-cholesterol or total serum cholesterol is decreased. The following section is devoted to reviewing the various types of fiber and their effect on serum lipids.

Oat Products

Several groups of investigators have assessed whether moderate intakes of oat products would induce a hypocholesterolemic effect in healthy individuals. Van Horn et al. (27) reported that a daily intake of 35 to 40 grams of oat bran or oatmeal with a fat-modified diet given to 208 healthy male and female subjects for twelve weeks lowered serum cholesterol levels by 5.2% ($p<0.05$) after six weeks. Anderson et al. (6) reported that LDL-cholesterol decreased by 36% ($p<0.02$) while HDL-cholesterol increased by 82% ($p<0.002$) when four healthy men were fed an oat bran supplement (100 g), and a cholesterol and fat restricted diet. When they gave 100 grams of oat bran daily without cholesterol or fat restriction to eight men, the average reduction in LDL-cholesterol levels was 14% ($p<0.05$) while HDL-cholesterol remained unchanged (6). Judd and Truswell (28) observed no significant reduction ($p<0.10 >0.05$) in plasma total cholesterol concentrations when 10 healthy subjects were given 125 grams of rolled oats daily without restricting fat or cholesterol intake. Anderson et al. (29) found that a diet containing oat bran (47 g total plant fiber and 17 g soluble fiber per day) given to 20 hypercholesterolemic men for three weeks lowered serum total cholesterol levels by 19% ($p<0.0005$) and LDL-cholesterol levels by 24% ($p<0.0005$).

Wheat Bran

Van Berge-Henegouwen et al. (30) added uncooked, powdered wheat bran (35.8-37.8 g/day) to the diets of seven healthy male subjects for four weeks. A reduction ($p<0.05$) was observed in total serum cholesterol (10%) and total serum triglycerides (24%). However, the HDL-cholesterol fraction also was reduced markedly during this study. Flanagan et al. (7) prescribed a high fiber diet (30 g All-Bran plus 30 g wheat bran daily) to 16 patients with normal blood lipids; after one month their HDL-cholesterol levels increased significantly ($p<0.05$).

Lindgarde and Larsson (31) conducted a placebo-controlled, double-blind, crossover study for two 8-week periods. Twelve hypercholesterolemic men and 14 normolipidemic men added a purified form of wheat fiber (10.5 g/day) to a lipid-lowering diet. The HDL-cholesterol concentration increased ($p<0.001$) from 1.1 mmol/l to 1.44 mmol/l in the hypercholesterolemic group, but remained unchanged in the normolidemic group.

Various Gums

Jenkins et al. (32) administered 5 grams of guar gum three times a day to hyperlipidemic patients for two weeks; serum cholesterol levels fell 10.6% ($p<0.01$) while there was no significant change in serum triglycerides. Jenkins

et al. (33) gave hyperlipidemic patients 13 grams of guar gum in crispbread form over an 8-week period. Significant reductions in both total and LDL-cholesterol of 13% ($p<0.002$) and 16% ($p<0.02$), respectively, were observed. HDL-cholesterol levels remained unchanged.

Behall et al. (34) observed a decrease ($p<0.001$) in total serum cholesterol and plasma LDL-cholesterol after carboxoymethylcellulose gum, locust bean gum, and karaya gum were consumed by 12 healthy men for four weeks at the level of 0.75 g fiber/100 kcal. The HDL/VLDL + LDL-cholesterol ratio was higher ($p<0.05$) when carboxymethyl-cellulose gum was added to a basal diet.

Soya Fiber

Several investigators studied the effect of dietary fiber from soybean on serum lipids. Schweizer et al. (8) supplemented normal diets of six healthy subjects with 21 grams of dietary fiber from either a nonpurified, never-dried soya pulp or a purified soya fiber for three weeks each. The nonpurified, never-dried soya pulp had no significant effect on blood lipids or the lipoprotein components. However, the purified soya fiber increased LDL-cholesterol by 19% ($p<0.01$) and LDL-lipoprotein-phospholipids by 16% ($P<0.05$). These results indicated that dietary fibers from soybean did not seem to contribute to

the hypocholesterolemic effect of soya. A diet controlled, crossover design study by Tsai et al. (35) was conducted to determine the effect of soya polysaccharide (25 g/day) on blood lipid levels. After two 17-day feeding periods, there were no significant changes in serum lipid levels of 14 healthy male college students.

Pectin

Kay and Turswell (36) gave nine healthy subjects (four men and five women, aged 21-28 yrs) 15 grams of citrus pectin per day in gel form for three weeks in addition to metabolically controlled diets. A reduction ($p<0.001$) in plasma cholesterol concentrations was observed while plasma triglyceride levels remained unchanged. Stausse-Wolthuis et al. (37) divided 62 healthy volunteers (40 men and 22 women, aged 18-28 yrs) into four groups. Group 1 received a low-fiber diet (6 g total dietary fiber/day); group 2 received a high-fiber diet (16 g total dietary fiber/day) rich in fruits and vegetables; group 3 followed a low-fiber diet in which 9 grams of citrus pectin was added daily; and group 4 received a low-fiber diet supplemented with 13 g of wheat bran daily. Serum total cholesterol decreased ($p<0.01$) by 0.34 mmol/l in those subjects on the citrus pectin supplemented diet. The high-fiber diet containing fruits and vegetables nonsignificantly decreased serum

total cholesterol by 0.17 mmol/l. The low-fiber diet supplemented with wheat bran increased ($p<0.01$) serum total cholesterol concentrations by 0.34 mmol/l. Serum HDL-cholesterol concentrations were not significantly affected by the amount or type of dietary fiber. Nakamura et al. (38) reported that 9 grams of pectin given daily to 12 hypercholesterolemic inpatients nonsignificantly decreased serum cholesterol by 9.5% and LDL-cholesterol by 10.5%.

Multiple Types of Fiber

Mesink and Katan (39) had 24 healthy subjects follow a high-carbohydrate diet which included bread, pulses, vegetables, potatoes, fruits, and jam (6 g dietary fiber/day) for 36 days. Nonsignificant reductions in serum cholesterol and HDL-cholesterol were observed while triglycerides increased nonsignificantly. Ullrich and Albrink (5) conducted a double crossover design study for four days. A 72% carbohydrate diet, either high or low in dietary fiber was given to eight healthy male subjects. Total and HDL-cholesterol levels decreased significantly ($p<0.05$) with both a high or low fiber diet. Stausse-Wolthuis et al. (2) conducted a crossover study in which 46 healthy subjects (23 men and 23 women, aged 20-27 yrs) consumed a high-fiber diet (45 g total dietary fiber and 6.2 g pectin/day) and a low-fiber diet (12 g total dietary fiber and 1.3 g pectin/

day). Half of the total dietary fiber came from fruits and vegetables and the other half from bread and cereal products. Half of the subjects followed a high cholesterol diet (600 mg/day) and the other half a low cholesterol diet (200 mg/day). A high-fiber diet decreased total serum cholesterol concentrations by 0.44 mmol/l ($p<0.01$) with high cholesterol and 0.31 mmol/l ($p<0.002$) with a low cholesterol regime.

Munoz et al. (3) reported that total plasma cholesterol decreased 12.0% ($p<0.05$) when healthy male subjects were given hard red spring wheat bran (26 g/day). Total plasma cholesterol also decreased by 14% ($p<0.05$) with soybean hulls (26 g/day). LDL-cholesterol decreased 21.0% ($p<0.05$) with hard red spring wheat bran. HDL-cholesterol levels remained unchanged with any of the dietary fiber sources. All sources of dietary fiber decreased triglyceride levels significantly ($p<0.01$). Kay et al. (4) reported an inverse correlation between dietary fiber intake and levels of total cholesterol ($p<0.01$) and triglycerides ($p<0.05$) in a multivariate analysis of 200 healthy men. Nakamura et al. (38) reported that the level of serum LDL + VLDL-cholesterol was significantly reduced ($p<0.01$) when nine healthy subjects were given 6 to 12 grams of Ishabgul (Isapola) granule.

In summary, moderate intakes of oat products lowered total serum cholesterol and LDL-cholesterol levels significantly. When fat and cholesterol intake was restricted along with dietary intake of oat products, HDL-cholesterol levels were increased significantly. Dietary intake of wheat bran seemed to reduce total serum cholesterol and triglycerides significantly in healthy subjects. HDL-cholesterol levels increased significantly when hypercholesterolemic men were given wheat bran and healthy subjects followed a wheat bran supplemented, fat restricted diet. Various gums seemed to significantly decrease total serum cholesterol and LDL-cholesterol levels in hyperlipidemic and healthy patients, but had no effect on HDL-cholesterol levels. Dietary fiber from soybean did not significantly affect blood lipids. Healthy subjects given 9-15 grams of citrus pectin decreased their total serum cholesterol levels significantly. One can conclude that several factors determine the effect that dietary fiber intake has on blood lipids such as the type and amount of fiber, fat and cholesterol intake, and normal or elevated blood lipids.

EFFECT OF EXERCISE ON BLOOD LIPIDS

Liebman et al. (40) reported that 13 male subjects, aged 24 to 35 years, who participated in a 12-week exercise training program (4 mile walk-jog-run sessions, 3 times/

week) had an increase ($p<0.05$) of plasma HDL-cholesterol levels and HDL-cholesterol to LDL-cholesterol ratios. A decline ($p<0.05$) of triglycerides was observed at week 12 for the exercised subjects, after a rise in triglycerides at week 6 had been observed. Clarkson et al. (10) examined the total and HDL-cholesterol levels of 28 well-trained weight lifters, six distance runners, and 17 controls, aged 18-29 years. The runners had lower ($p<0.05$) total cholesterol, higher HDL percent, and lower total cholesterol/HDL-cholesterol ratio ($p<0.01$) than both weight lifters and controls. The results suggested that persons involved in aerobic exercise demonstrated beneficially lower total cholesterol/HDL-cholesterol levels than those involved in anaerobic exercise programs. Johnson et al. (11) reported similar observations. The volunteers who ran approximately 10 kilometers per week had significantly lower total serum cholesterol levels than the weight lifting or inactive group. No significant changes in triglycerides were observed. Lopez et al. (12) reported that after a 7-week program of brief, but intense exercise in medical students an increase of HDL-cholesterol levels was observed.

MATERIALS AND METHODS

SUBJECTS

Twenty-six healthy female subjects, aged 20 to 32 years, were divided into three groups according to their physical activity level. Ten subjects who were not engaged in a regular exercise program were in the inactive control group. Ten subjects who ran approximately 25 miles per week made up a group of low-mileage runners. Six subjects who ran approximately 45 miles per week were in the group of high-mileage runners. Williams (41) has reported the effects of running on body composition and caloric intake of these subjects. Sadeghian (42) analyzed and reported blood lipid values of these subjects.

DIETARY ANALYSIS

Subjects completed a 7-day diet record. Total calories, protein, carbohydrate, total fat, saturated fat, cholesterol, alcohol, and crude fiber intakes were calculated for each subject using a computer nutrient analysis program that included data from Agricultural Handbooks Number 456, "Nutritive Value of American Foods" and Number 8-1 through 8-9, "Composition of Foods" (42). Anderson's "Plant Fiber in Foods" (43) was used to hand calculate total and soluble fiber intake.

STATISTICAL ANALYSIS

Analysis of variance was used to determine whether there were significant differences in nutrient intakes and serum lipid values among the groups. Correlation coefficients and partial correlation coefficients were determined to assess the relationship between intakes of seven nutrient and five serum lipid variables using the Pearson product moment correlation formula.

RESULTS

DIETARY FACTORS

Mean daily intakes of protein, carbohydrate, total fat, cholesterol, and crude fiber of the three groups of subjects, as determined by Sadeghian (42), using the nutrient data base from the USDA and dietary fiber reported as total and soluble dietary fiber calculated by using the 1986 "Plant Fiber in Foods" composition book of Anderson (43) are shown in Table 1, along with the pooled estimates of standard deviation computed from the analyses of variance. There were no significant differences among the three groups in dietary intakes of total, soluble, and crude fiber, protein, carbohydrate, total fat, and cholesterol. The high mean values for protein, fat, and cholesterol for the high-mileage group were caused by one subject who ate excessive amounts of eggs and cheese daily.

TOTAL AND SOLUBLE FIBER INTAKE

The variation of total and soluble fiber intake on an individual, daily, and weekly basis is shown in Table 2. An average fiber intake of the groups may increase as the level of activity increases in the group; this observed trend was nonsignificant. There were great variations in total and soluble fiber intake on an individual, daily, and weekly basis.

Table 1. Mean nutrient intakes for each group.*

Variable	Inactive (n=10) gm	Low-mileage (n=10) gm	High-mileage (n=6) gm	Pooled** S.D.
Dietary total fiber	9.7	12.7	14.6	6.7
Dietary soluble fiber	3.0	3.5	4.5	2.0
Dietary crude fiber	3.5	4.8	5.4	2.2
Dietary protein	66.2	62.1	88.0	29.7
Dietary carbohydrate	228.1	201.9	219.4	61.5
Dietary total fat	71.9	66.4	70.4	28.0
Dietary cholesterol	292.1	225.0	623.8	462.4

*Values are means over a 7-day period. Results given as mean are for each group separately.

**Pooled estimate of standard deviation within activity groups using 23 DF.

Table 2. Total and soluble dietary fiber intake for seven days.

Subject number	Dietary fiber: Total/day (gm) 1	2	3	4	5	6	7	av	Soluble/day (gm) 1	2	3	4	5	6	7	av
Inactive subjects (n=10)																
1	9.9	15.9	9.8	11.2	6.3	12.3	7.9	10.5	3.0	4.9	1.7	3.0	1.4	3.7	1.9	2.8
2	4.0	11.8	3.7	8.4	2.9	7.6	0.8	5.6	0.9	5.5	1.2	1.8	1.1	2.8	0.3	1.9
3	10.1	4.9	4.8	10.1	12.8	8.6	9.1	8.6	4.3	1.8	1.7	4.1	4.9	3.0	3.4	3.3
4	11.5	13.9	14.3	19.5	4.1	11.2	11.5	12.3	3.7	4.4	4.0	4.2	1.0	3.0	4.4	3.5
5	6.5	7.9	3.6	8.4	8.9	7.3	5.6	6.9	1.6	2.2	1.4	3.3	3.1	1.8	1.4	2.1
6	14.4	18.3	18.1	21.0	16.6	18.0	11.1	16.8	4.1	5.6	6.2	8.5	5.8	5.7	4.1	5.7
7	13.1	12.3	8.1	8.0	6.8	11.3	12.9	10.4	3.5	3.1	2.5	2.4	2.2	2.9	3.6	2.9
8	8.5	5.2	15.0	8.5	8.6	6.5	16.0	9.8	2.9	1.7	4.8	3.2	2.7	2.4	5.9	3.4
9	10.1	4.6	2.2	1.0	3.0	5.4	11.1	5.3	2.7	1.9	1.9	0.4	1.2	2.1	3.1	1.8
10	8.8	2.9	11.2	27.3	10.2	3.4	11.4	10.7	2.3	0.8	2.7	8.9	3.4	1.0	2.9	3.1
av.								9.7								3.0
Low-mileage runners (n=10)																
1	15.0	5.7	5.2	15.4	0.8	6.4	0.5	6.8	3.9	1.4	2.1	6.6	0.2	1.7	0.2	2.2
2	20.5	15.7	12.5	13.8	22.3	15.5	19.1	17.0	5.8	4.5	3.3	3.0	7.3	3.6	5.6	4.7
3	8.8	0.0	2.0	5.9	3.3	0.2	4.8	3.6	2.2	0.0	0.6	2.0	1.4	0.1	1.4	1.1
4	40.7	19.0	19.0	30.7	26.3	15.5	38.1	27.0	11.8	3.4	5.4	8.3	6.6	5.5	9.0	7.1
5	17.3	13.7	35.4	13.1	8.7	16.2	9.1	16.2	4.8	4.3	8.0	3.5	2.3	3.5	3.6	4.3
6	24.9	7.2	15.6	6.7	9.4	18.5	29.2	15.9	5.0	1.7	3.9	2.5	2.0	3.9	8.3	3.9
7	7.2	14.2	18.3	9.2	4.4	12.0	9.0	10.6	2.0	5.5	5.3	2.7	1.0	2.3	2.6	3.0
8	9.0	3.8	4.1	8.8	5.5	5.8	2.5	5.6	3.1	1.0	1.1	1.1	2.6	2.6	1.0	1.8
9	10.8	8.2	4.5	1.7	9.3	12.2	5.7	7.5	2.3	3.5	2.0	0.5	3.4	3.2	2.2	2.4
10	22.1	18.0	20.3	4.0	7.2	19.0	26.5	16.7	4.9	4.0	4.2	1.8	1.7	4.7	7.5	4.1
av.								12.7								3.4

Table 2. continued.

Subject number	Dietary fiber: Total/day (gm) 1	2	3	4	5	6	7	av	Soluble/day (gm) 1	2	3	4	5	6	7	av
									High-mileage runners (n=6)							
1	4.9	0.0	0.0	3.4	5.9	6.0	4.3	3.5	1.8	0.0	0.0	0.5	1.3	2.4	1.6	1.1
2	10.9	5.6	8.3	15.5	11.7	10.6	3.6	9.4	2.2	1.5	2.2	4.1	3.1	4.2	1.0	3.0
3	6.1	8.8	8.8	11.8	15.0	17.4	9.1	11.0	1.7	2.6	2.4	3.4	5.3	6.6	3.2	3.6
4	28.3	47.9	26.7	15.8	25.6	37.6	20.5	28.9	7.7	21.3	8.9	4.5	6.7	13.8	8.5	10.2
5	22.1	22.1	25.7	23.4	26.1	19.5	28.1	23.8	5.0	6.1	7.4	5.9	6.9	5.1	7.6	6.3
6	17.3	15.5	9.0	6.2	7.2	15.3	8.8	11.3	4.0	6.8	2.2	2.1	2.6	3.0	3.1	3.4
av.								14.6								4.5

SERUM LIPIDS

Mean serum levels of total cholesterol, lipoprotein-cholesterol, and triglycerides for the inactive, low-mileage, and high-mileage groups are presented in Table 3. There were differences ($p=0.02$) for the mean of total serum cholesterol, LDL-cholesterol, and LDL + VLDL-cholesterol between the low-mileage runners and the high-mileage runners. There were no significant differences for the mean values of HDL-cholesterol and triglycerides among the three groups.

CORRELATIONS BETWEEN DIETARY FIBER INTAKE AND OTHER DIETARY COMPONENTS

Correlation coefficients of dietary fiber intake and other dietary components for all groups and each group separately are shown in Table 4. Total, soluble, and crude fiber intake correlated positively and significantly with carbohydrate intake ($p<0.01$, $p<0.001$, $p<0.001$, respectively) for all groups. There were no significant correlations between dietary fiber intake and protein, carbohydrate, fat, and cholesterol intakes in the inactive subjects.

Total and soluble fiber intakes correlated positively ($p<0.10$) with carbohydrate intake for the low-mileage runners. A significant correlation was found between crude fiber and carbohydrate intake ($p<0.05$) in the low-mileage group. Negative correlations existed between total,

Table 3. Mean serum lipid values for each group.*

Variable	Inactive (n=10) mg/dl	Low-mileage (n=10) mg/dl	High-mileage (n=6) mg/dl	Pooled** S.D.
Total cholesterol	154.6 a	162.2 a	191.0 b	23.9
HDL-cholesterol***	56.2 a	61.1 a	61.2 a	10.8
LDL-cholesterol***	85.5 a	91.8 a	115.7 b	18.9
LDL+VLDL-cholesterol***	91.4 a	94.8 a	118.7 b	17.8
Triglycerides	63.1 a	47.1 a	65.2 a	21.1

*p=0.02.
**Pooled estimate of S.D. within activity groups using 23 DF.
***HDL = high density-lipoprotein; LDL = low density-lipoprotein; VLDL = very low density lipoprotein.

Table 4. Correlation coefficients (r) of dietary fiber intake and dietary intakes of protien, carbohydrate, fat, and cholesterol.

Dietary fiber fractions (gm)	Dietary variables			
	Protein	Carbohydrates	Fat	Cholesterol
		All subjects (n=26)		
Total	0.165	0.586**	-0.252	-0.011
Soluble	0.182	0.654***	-0.188	-0.012
Crude	0.109	0.611***	-0.240	-0.067
		Inactive subjects (n=10)		
Total	0.530	0.075	-0.107	0.241
Soluble	0.361	0.235	-0.006	0.312
Crude	0.495	0.104	0.187	0.324
		Low-mileage runners (n=10)		
Total	0.105	0.566 †	-0.669*	0.122
Soluble	0.154	0.579 †	-0.652*	0.194
Crude	0.088	0.684*	-0.583 †	0.047
		High-mileage runners (n=6)		
Total	0.084	0.984***	-0.049	-0.158
Soluble	0.074	0.959***	-0.033	-0.152
Crude	-0.014	0.954**	-0.131	-0.243

†p<0.10; *p<0.05; **p<0.01; ***p<0.001.

soluble, and crude fiber and fat intake ($p<0.05$, $p<0.05$, $P<0.01$, respectively) for the low-mileage runners.

A positive correlation ($p<0.001$) was found between total and soluble fiber intakes and carbohydrate intake in the high-mileage runners (group 3). Crude fiber intake correlated positively ($p<0.01$) with carbohydrate intake for the high-mileage runners.

Partial correlation coefficients of dietary fiber intake and other dietary components for all subjects are shown in Table 5. Total and soluble fiber intake correlated positively and significantly ($p<0.01$ and $p<0.001$) with carbohydrate intake. A positive ($p<0.001$) correlation existed between crude fiber and carbohydrate intake.

CORRELATIONS BETWEEN DIETARY FACTORS AND SERUM LIPIDS

Fiber Intake

Correlation coefficients of dietary fiber intakes and serum lipids of all subjects and each group separately are shown in Table 6. There were no significant correlations between dietary fiber intake and serum lipid values when groups were pooled. There was a nonsignificant negative correlation between total fiber intake and triglycerides, soluble fiber intake and HDL-cholesterol, and crude fiber intake and HDL-cholesterol levels in all subjects.

Table 5. Partial correlation coefficients (r) of dietary fiber intake and dietary intakes of protein, carbohydrate, fat and cholesterol.

Dietary fiber fractions	Dietary variable			
	Protein	Carbohydrate	Fat	Cholesterol
		All subjects (n=26)		
Total	0.114	0.662**	-0.251	-0.080
Soluble	0.106	0.708***	-0.194	-0.081
Crude	0.046	0.709***	-0.239	-0.150

**p<0.010
***p<0.001

Table 6. Correlation coefficients (r) of dietary fiber intakes with serum lipid values.

Dietary fiber fractions	Serum cholesterol				Serum triglycerides
	Total	HDL	LDL	LDL+VLDL	
			All subjects (n=26)		
Total	0.119	0.026	0.163	0.141	-0.036
Soluble	0.977	-0.021	0.106	0.112	0.092
Crude	0.095	-0.022	0.138	0.140	0.056
			Inactive subjects (n=10)		
Total	-0.555†	-0.507†	-0.409	-0.495	-0.205
Soluble	-0.477	-0.415	-0.353	-0.440	-0.207
Crude	-0.287	-0.323	-0.235	-0.213	0.079
			Low-mileage runners (n=10)		
Total	0.469	0.677**	0.329	0.295	-0.482
Soluble	0.446	0.681**	0.300	0.262	-0.486
Crude	0.364	0.616†	0.234	0.209	-0.511
			High-mileage runners (n=6)		
Total	-0.567	-0.551	-0.264	-0.165	0.558
Soluble	-0.579	-0.471	-0.378	-0.211	0.706
Crude	-0.625	-0.609	-0.304	-0.190	0.630

†$p<0.10$
**$p<0.01$

In the inactive subjects, total fiber intake correlated negatively ($p<0.10$) with the level of total serum cholesterol and HDL-cholesterol. In the low mileage runners, positive correlations were found between total and soluble fiber intakes and HDL-cholesterol level ($p<0.01$). Crude fiber intake and HDL-cholesterol also correlated positively ($p<0.10$) in the low-mileage group. In the high-mileage group, no significant correlations were found between dietary fiber intake and serum lipid values.

Partial correlation coefficients of dietary fiber intake and serum lipid values for the inactive subjects, low-mileage runners, and high-mileage runners are shown in Table 7. There were no significant partial correlations between dietary fiber and serum lipid values for the three groups.

Other Dietary Factors

Correlation coefficients of dietary protein, carbohydrate, fat, and cholesterol intakes with serum lipid values for all subjects and each group separately are shown in Table 8. In all subjects ($n=26$), protein intake correlated positively with the level of total serum cholesterol, HDL-cholesterol, and LDL + VLDL-cholesterol ($p<0.05$) and LDL-cholesterol ($p<0.01$). Cholesterol intake correlated positively and significantly with the level of total serum

Table 7. Partial correlation coefficients (r) of dietary fiber intake and serum lipid values.

Dietary fiber fractions	Serum cholesterol				Serum triglycerides
	Total	HDL	LDL	LDL+VLDL	
			All subjects (n=26)		
Total	-0.025	-0.041	0.023	0.008	-0.016
Soluble	-0.095	-0.074	-0.067	-0.053	0.077
Crude	-0.078	-0.107	-0.033	-0.013	0.100

Table 8. Correlation coefficients (r) of dietary protein, carbohydrate, fat, and cholesterol with serum lipid values.

Dietary variable	Serum cholesterol				Serum triglycerides
	Total	HDL	LDL	LDL+VLDL	
			All subjects (n=26)		
Protein	0.441*	0.274*	0.428**	0.457*	-0.005
Carbohydrate	-0.076	-0.093	-0.039	0.013	0.078
Fat	0.293	0.264	0.226	0.301	0.098
Cholesterol	0.471*	0.358†	0.424**	0.485*	-0.028
			Inactive subjects (n=10)		
Protein	0.004	-0.322	0.285	0.126	-0.153
Carbohydrate	-0.340	0.007	-0.359	-0.302	-0.348
Fat	0.619†	0.526	0.507	0.593†	0.227
Cholesterol	0.524	-0.528	0.430	0.402	-0.222
			Low-mileage runners (n=10)		
Protein	0.376	0.130	0.397	0.265	0.173
Carbohydrate	0.375	0.480	0.253	0.271	-0.090
Fat	0.012	-0.333	0.062	0.070	0.574†
Cholesterol	0.379	0.609†	0.184	0.187	0.036
			High-mileage runners (n=6)		
Protein	0.752†	0.528	0.529	0.643	-0.203
Carbohydrate	-0.416	-0.477	-0.135	-0.011	0.530
Fat	0.817*	0.629	0.515	0.644	-0.213
Cholesterol	0.884*	0.639	0.598	0.706	-0.291

† $p<0.10$, * $p<0.05$, ** $p<0.01$

cholesterol and LDL + VLDL-cholesterol ($p<0.05$), LDL-cholesterol ($p<0.010$), and HDL-cholesterol level ($p<0.10$) in all subjects.

A positive correlation between fat intake and the levels of total serum cholesterol and LDL + VLDL-cholesterol ($p<0.10$) existed in the inactive subjects. In the low-mileage runners, fat intake and the level of triglycerides correlated positively ($p<0.10$). A positive correlation existed between cholesterol intake and the level of HDL-cholesterol ($p<0.10$) in the low-mileage group. Protein intake correlated positively ($p<0.10$) with total serum cholesterol level in the high-mileage runners. Fat and cholesterol intakes and total serum cholesterol level correlated positively ($p<0.05$) for the high-mileage runners.

Partial correlation coefficients of dietary protein, carbohydrate, fat, and cholesterol intakes with serum lipid values for all subjects ($n=26$) are summarized in Table 9. Dietary protein and fat intakes correlated positively ($p<0.10$) with total serum cholesterol and LDL + VLDL-cholesterol levels. A positive correlation existed between cholesterol intake and total serum cholesterol, HDL-cholesterol, and LDL + VLDL-cholesterol levels ($p<0.10$).

Table 9. Partial correlation coefficients (r) of dietary protein, carbohydrate, fat, and cholesterol with serum lipid values.

Dietary variable	Serum cholesterol				Serum triglycerides
	Total	HDL	LDL	LDL+VLDL	
			All subjects (n=26)		
Protein	0.345†	0.274	0.326	0.356†	-0.105
Carbohydrate	-0.077	0.058	-0.032	0.018	0.010
Fat	0.349†	0.289	0.274	0.355†	0.070
Cholesterol	0.386†	0.367†	0.323	0.393†	-0.132

†$p<0.10$

FOOD FREQUENCY RECORD OF DIETARY FIBER INTAKE

Table 10 summarizes the food frequency record of dietary fiber intake for all subjects. The results indicated that the subjects' main source of dietary fiber was the bread, cereal, or pasta group. The subjects consumed more insoluble fiber from grain and vegetable sources than soluble fiber in fruit. The high-mileage group consumed more servings of bread, cereal, vegetable, and fruit than the low-mileage or inactive groups.

Table 10. Food frequency record of dietary fiber intake for 7-day period.

Subject number	Number of times/week		
	Bread, cereal or pasta	Vegetables	Fruit
	Inactive subjects (group 1/n=10)		
1	25	32	5
2	8	4	6
3	14	10	8
4	14	9	6
5	17	11	5
6	38	27	17
7	20	17	12
8	19	23	13
9	12	9	5
10	13	17	15
Av.	18	16	9
	Low-mileage runners (group 2/n=10)		
11	12	11	5
12	21	21	14
13	9	12	2
14	26	36	18
15	20	34	15
16	36	10	12
17	15	14	4
18	13	3	2
19	9	10	6
20	35	7	6
Av.	20	16	8

Table 10. Continued.

Subject number	Number of times/week		
	Bread, cereal or pasta	Vegetables	Fruit
		High-mileage runners (group 3/n=6)	
21	8	9	3
22	21	11	15
23	22	22	12
24	17	24	20
25	30	42	25
26	21	10	2
Av.	20	20	13

DISCUSSION

The type and amount of dietary fiber in addition to fat and cholesterol consumption may explain the results of dietary fiber intake correlations with serum lipid values of the three groups (see Table 6). For inactive subjects, as total dietary fiber intake increased, total serum cholesterol and HDL-cholesterol levels decreased. Van Berge-Henegouwen et al. (30) found that total serum cholesterol and HDL-cholesterol levels were reduced significantly with the ingestion of wheat bran. The present findings indicated that the major source of fiber intake by the inactive subjects was from wheat sources (food frequency record shown in Table 10).

In the low-mileage runners, a significant positive correlation was found between total, soluble, and crude fiber intakes and HDL-cholesterol levels. Anderson et al. (6) found that HDL-cholesterol levels significantly increased when the subjects had an oat bran supplemented, fat and cholesterol restricted diet. Our findings suggested that an increase in HDL-cholesterol levels may have been the result of the consumption of oat products and/or low intakes of fat and cholesterol (Table 1) in the low-mileage runners.

In the high-mileage runners, no significant correlations were found between dietary fiber intake and

serum lipid values. There are several hypotheses that can be postulated why no significant results were obtained. The high-mileage runners had the highest dietary fiber intake among the three groups consisting of bread, cereal, or pasta, vegetables, and fruit sources. Mesink and Katan (39) found no significant reductions in total serum cholesterol level when healthy subjects consumed a high-fiber diet including bread, cereals, vegetables, and fruit. Stausse-Wolthuis et al. (37) found a nonsignificant reduction in total serum cholesterol when healthy subjects received a high-fiber diet (16 g total dietary fiber/day) containing fruits and vegetables. The misleading high cholesterol intake of the high-mileage runners due to the extremely high cholesterol intake of one runner (2591 mg/day) may have contributed to the nonsignificant results.

In conclusion, several factors may determine the effect that dietary fiber intake has on blood lipids such as the type and amount of fiber, fat, and cholesterol intake, and the type and amount of exercise. The significant correlations between dietary fiber intake and serum lipid values in the inactive and low-mileage groups may be attributed to the lower intakes of fat and cholesterol compared to the high-mileage group. Also the type of fiber may have been another factor. The inactive and low-mileage runners consumed more fiber from grains

(i.e. wheat bran and oat bran) and less from fruit. Several investigators have found that a diet high in wheat or oat bran produced greater alterations in blood lipids than a high-fiber diet consisting of bread, cereal, vegetables, and fruit. Further research is needed to determine the exact type and amount of dietary fiber needed to have significant selective alterations on serum lipid levels in humans.

SUMMARY

Recent research has focused on the effects of diet composition and exercise on serum lipid levels. The purpose of this study was to determine whether there were differences in total and soluble fiber intake among young women who participated in regular running programs and sedentary controls. In addition, the relationship of dietary fiber intake to serum lipids was studied.

Twenty-six healthy female subjects, aged 20 to 32 years, were divided into three groups according to their physical activity level. Ten inactive controls were not engaged in a regular exercise program, ten low-mileage runners ran approximately 25 miles per week, and six high-mileage runners ran approximately 45 miles per week. Subjects completed a 7-day diet record in which the mean intakes of protein, carbohydrate, fat, and crude fiber were computed using a nutrient data base from the USDA. Total and soluble fiber intakes were hand calculated from Anderson's "Plant Fiber in Foods" table.

There were no significant differences among the three groups in dietary intakes of total, soluble, and crude fiber, protein, carbohydrate, total fat, and cholesterol. There were significant differences for total serum cholesterol, LDL-cholesterol, and LDL + VLDL-cholesterol between the low-mileage runners (group 2) and the

high-mileage runners (group 3). There were no significant differences for the mean values of HDL-cholesterol and triglycerides among the three groups.

There were no significant correlations between dietary fiber intake and serum lipid values in all subjects (n=26). However, in the inactive group, total fiber intake correlated negatively with the level of total serum cholesterol and HDL-cholesterol. In the low-mileage runners, a positive correlation was found between total, soluble, and crude fiber intake and HDL-cholesterol level. In the high-mileage group, no significant correlations were found between dietary fiber intake and serum lipid values. The food frequency record of dietary fiber intake indicated that the subjects' main source of dietary fiber came from the bread and cereal group. The subjects consumed more insoluble fiber from grain sources and vegetables than soluble fiber from fruit. The high-mileage runners consumed more servings of bread, cereal, vegetables, and fruit than the low-mileage or inactive groups.

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TOTAL AND SOLUBLE DIETARY FIBER INTAKE OF FEMALE RUNNERS

by

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of
the requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1988

Recent research has focused on the effects of diet composition and exercise on serum lipid levels. The purpose of this study was to determine whether there were differnces in total and soluble fiber intake among young women who participated in regular running programs and sedentary controls. In addition, the relationship of dietary fiber intake to serum lipids was studied.

Twenty-six healthy female subjects, aged 20 to 32 years, were divided into three groups according to their physical activity level. Ten inactive controls were not engaged in a regular exercise program, ten low-mileage runners ran approximately 25 miles per week, and six high-mileage runners ran approximately 45 miles per week. Subjects completed a 7-day diet record in which the mean intakes of protein, carbohydrate, fat, and crude fiber were computed using a nutrient data base from the USDA. Total and soluble fiber intakes were hand calculated from Anderson's "Plant Fiber in Foods" table.

There were no significant differences among the three groups in dietary intakes of total, soluble, or crude fiber, protein, carbohydrate, total fat, and cholesterol. There were significant differences for total serum cholesterol, LDL-cholesterol, and LDL + VLDL-cholesterol between the low-mileage runners (group 2) and the high-mileage runners (group 3). There were no significant differences

for the mean values of HDL-cholesterol and triglycerides among the three groups.

There were no significant correlations between dietary fiber intake and serum lipid values in all subjects (n=26). However, in the inactive group, total fiber intake correlated negatively with the level of total serum cholesterol and HDL-cholesterol. In the low-mileage runners, a positive correlation was found between total, soluble, and crude fiber intake and HDL-cholesterol level. In the high-mileage group, no significant correlations were found between dietary fiber intake and serum lipid values. The food frequency record of dietary fiber intake indicated that the subjects' main source of dietary fiber came from the bread and cereal group. The subjects consumed more insoluble fiber from grain sources and vegetables than soluble fiber from fruit. The high-mileage runners consumed more servings of bread, cereal, vegetables, and fruit than the low-mileage or inactive groups.